EXPERIMENTAL INVESTIGATION ON COMPRESSION AND FRACTURE BEHAVIOUR OF CONCRETE BY FLY ASH AND SILICA FUMES

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Abstract:
The effects of replacing cement by fly ash and silica fume on strength, compressive stress-strain relationship, and fracture behaviour concrete has been investigated. To study these properties of concrete, it was categorized in to two groups with two water cement ratios of 0.35 and 0.4. Five types of mix proportions were used to cast the test specimens for both groups. The replacement levels of OPC by silica fumes were 0%, 10%, 20%,and 25%, where replacement levels by Fly Ash were 0%, 10%, 20%, and 25%. All these specimens are tested for 28 days strength. 20% of silica fumes and 20% of fly ash where found to be optimum for maximum compressive strength, maximum split tensile strength at low cost than that of conventional concrete. The examination secured concrete mixes at various water-cementitious material proportions, which contained low and high volumes of fly ash remains, and with or without the expansion of limited quantity of silica fume. It was discovered that fly ash significantly improved the post-crest compressive conduct of concrete, with a generally littler inclination in the plummeting some portion of the pressure strain bend. Low volumes of fly ash improved the compressive strength of concrete and small amount silica fumes have shown better results. A small amount of silica fumes effects positively on tensile strength and high volume of fly ash decreases the tensile strength. Flexural strength has shown improvement with the decrease of fly ash content.

Introduction:

Concrete is comprised of three essential parts: water, total (sand, or rock) and Portland concrete. Bond, as a rule in powder structure, goes about as a coupling operator when blended with water and totals. This blend, or solid blend, will be emptied and solidify into the strong material. It is a composite material made out of coarse granular material (the total or filler) encased in a hard network of material that fills the space among the total particles and pastes them together. The heaviness of cement utilized worldwide is twice that of steel, wood, plastics, and aluminum joined. Solid's utilization in the cutting edge world is surpassed distinctly by that of normally happening water.

Fly powder use improves solid execution, making it more grounded, increasingly strong, and progressively impervious to substance assault.. Contingent on the source and cosmetics of the coal being scorched, the segments of fly ash debris shift significantly, yet all fly powder incorporates considerable measures of silicon dioxide (SiO_2) (both undefined and crystalline) and calcium oxide (CaO), both being endemic fixings in many coal-bearing rock strata. Since the particles set quickly while suspended in the fumes gases, fly ash debris particles are commonly circular fit as a fiddle and range in size from 0.5 µm to 300 µm. Two classes of fly powder are characterized by ASTM C618: Class F fly slag and Class C fly cinder.

1.1 Objectives Of The Project:

- The principle target of the venture is to decide the improvement of solidarity of cement by consolidating fly cinder and silica exhaust. To think about the break conduct of cement by substitution of fly powder and silica exhaust.

- To ponder the compressive quality, split rigidity and flexural quality properties of cement with fly ash remains and silica in specific extents.
- To use volume of silica vapor and fly powder in cement up to 5%and 30% separately.
- To analyse the quality of cement between somewhat supplanted fly ash debris concrete and the solid with expansion of silica.
- To analyse crack vitality of cement by supplanting fly ash debris and silica exhaust.

Review Of Literature:

Watcharapong Wongkeo, Pailyn Thongsanitgarn and Arnon Chaipanich-2011 concentrated the physical properties, compressive quality and drying shrinkage of multi-mixed concrete under various restoring techniques. Fly cinder, ground base ash debris and undensified silica smoke were utilized to supplant some portion of concrete up to half by weight. From this exploration, the compressive quality of mixed concrete with FA and BA (ternary mixed bond) under various restoring conditions added to a lower compressive quality than that of PC control.

Mehmet Gesog˘lu, et al - 2012 revealed an exploratory examination on the mechanical properties of steel fiber consolidated plain and silica smolder (SF) cements created with virus reinforced fake fly ash remains totals (AFAs). The creation of cements with fake virus reinforced fly ash debris totals having appropriate mechanical properties was demonstrated to be conceivable through fuse of silica smoke and steel filaments. Utilization of SF as a substitution material gave improved mechanical properties of cements when contrasted with plain ones for both w/c proportions. The consideration of steel strands additionally added to the compressive quality.

Alireza Bagheri et al - 2013 Investigated the likelihood of utilizing fine fly ash debris in double and ternary blends with the point of beating the somewhat moderate rate of solidarity improvement in cements containing ordinary fly cinders or upgrading their toughness was examined. The outcomes demonstrate that the rate of pozzolanic response of fine fly slag is just respectably higher than ordinary fly ash debris and the water request is marginally decreased. The aftereffects of tests on cement blends at equivalent water to folio proportion demonstrate that paired cement blends containing fine fly ash remains had to some degree lower water request contrasted with the ordinary fly powder blends.

Experimental Investigation

3.1 General:

The different materials used in this investigation are

- Ordinary Portland Cement (53 grade)
- Aggregate
- Fly ash (Class F)
- Silica Fumes
- Potable Water

3.2 Ordinary Portland Cement (OPC):

Portland bond is by a long shot the most widely recognized sort of concrete as a rule use the world over. This concrete is made by warming limestone (calcium carbonate) with little amounts of different materials, for example, mud to 1450 °C in an oven, in a procedure known as calcinations, whereby a particle of carbon dioxide is freed from the calcium carbonate to frame calcium oxide, or quicklime, which is then mixed with different materials that have been incorporated in with the general mish-mash.

3.3 Aggregate

Totals emphatically impact cement's newly blended and solidified properties, blend extents, and economy. Thus, determination of totals is a significant procedure.

Attributes that are considered include:

- grading
- durability
- particle shape and surface

3.4 Flyash :

Fly slag is a melded build-up of dirt minerals present in coal. The high temperature created when coal consumes in warm power plants, changes the earth minerals in coal powder into an assortment of melded fine particles of basically aluminum silicate piece. Fly cinder can be utilized in Portland bond cement to improve the presentation of the solid. According to ASTM C 618 – 1993[17] there are two classes of fly ash debris in particular class F and class C. Class F fly powder is created from consuming anthracite or bituminous coal and is pozzolanic in nature and class C is acquired from lignite or sub-bituminous coal.

Fig.3.1 Fly ash

3.5 Silica Fumes:

Silica smolder, otherwise called miniaturized scale silica, (CAS number 69012-64-2, and EINECS number 273-761-1) is an undefined (non-crystalline) polymorph of silicon dioxide, silica. It is a ultrafine powder gathered as a result of the silicon and ferrosilicon compound generation and comprises of round particles with a normal molecule width of 150 nm. The

Fig.3.2 Silica fumes

Table 3.2 Consistency of cement

Sl. No	Weight of water in (gms) W_1	Weight of cement in (gms) W_2	$(W_2/W_1) \times 10$	Depth of Penetration (mm)
1	75	300	40	6
2	78	300	38.4	5
3	81	300	37.03	6
4	84	300	35.7	6
5	87	300	34.48	5
6	90	300	33.3	6

As per IS 4031 [1968] it is in a range of 5 to 7 mm hence Pn=30% is taken.

Physical Properties of OPC53 grade used

S.NO	Property	Result
1	Normal consistency	29%
2	Specific gravity	3.15
3	Initial setting time	95minutes
4	Final setting time	220minutes
5	Soundness of cement	3.5mm
6	Fineness of cement	4.47%
7	Compressive strength 7days 14days 28days	21.194N/mm^2 38.4N/mm^2 53.58N/mm^2

Physical Properties of Fine aggregate Used

S.no	Property	Result
1	Fineness modulus	3.095
2	Specific gravity	2.589
3	Bulk Density a. Loose state b. Compacted state	1540kg/m^3 1660kg/m^3
4	Bulking	5%

3.9.1 Mineral Admixtures

Mineral admixtures are added to concrete as a piece of the cementitious material. They might be utilized as an expansion or as a section substitution of Portland bond in cement. This relies upon the properties of materials and the ideal impact of cement. Ideal measure of mineral admixtures are utilized to improve explicit solid properties, for example, functionality and quality.

The general points of interest of mineral admixtures are

1. It builds the hydration procedure and diminishes the porosity of cement.
2. It fills and shuts the pores or modifies the kind of pore structure.
3. It builds hydration items notwithstanding the filling impact of total.
4. It alters the reviewing of the segments to accomplish an ideal minimal.

Different forms of Micro Silica

Physical and Chemical Properties of Micro silica

S.NO	Property	Result
1.	Formor state	Ultrafineamorphouspow

2.	Color	Grey
3.	Odour	Odourless
4.	Specific gravity	2.2–2.3
5.	Bulk Density(kg/m^3)	660
6.	Specific Surface(m^2/g)	20.2
7.	Particle size,	≈0.5
8.	Moisture content	1%
9.	Silicon Dioxide	92.00%

3.11.3 Super plasticizers

Concrete requires a very high deform ability at low water cement ratio, hence chemical admixtures are inevitable and in particular, the high range water reducers also known as super-plasticizers. A number of super-plasticizers exist. The molecular weight of super-plasticizer may vary from 100 to 100000. The super-plasticizers can be classified in to the following four main categories.

3.13 MIX DESIGN

The Mix Design is done according to

Grade Designation : M25
Type of Cement :OPC 53 grade confirming to IS 8112
Maximum nominal size of aggregate : 20mm
Minimum cement content : 300 kg/m^3
Maximum water cement ratio : 0.45
Workability : 100 mm slump
Exposure condition : mild
Method of concrete placing : Manual placement
Degree of supervision : good
Type of aggregate : Crushed angular
Maximum cement (Opc) content : 450 kg/m^3

Table 3.3 BIS Mix Design

Mix proportioning	Cement (kg)	Water (kg)	Fine aggregate (kg)	Coarse aggregate (kg)	Fly ash (kg)
Per m^3	276.024	197.72	698.49	1132.80	118.296
Per bag of cement	50	22.5	92.57	138.5	15
Ratio	1	0.45	1.85	2.77	0.30

Table 3.5 Fly ash replaced concrete with addition of Silica fumes specimen details

Grade of concrete	Fly ash replacement	Silica as an additive	No. of cubes for 7 days	No. of cubes for 28 days	No. of cylinders for 28 days	No. of beams for 28 days
	0%	5%	3	3	3	3

M25	10%	5%	3	3	3	3

RESULTS AND DISUSSION

4.1 COMPRESSIVE STRENGTH

The compressive quality of 150x150x150 mm solid shapes of M25 evaluation concrete with 0%, 10%, 20% and 30% of bond supplanted with fly ash remains. Compressive quality of cement with 10% level of fly cinder substitution on an expansion of 5% Silica for 7 and 28 days are appeared in table 4.1 and Figures 4.2 and 4.3 separately. It is seen that the quality of cement is decreased when the level of fly powder is expanded. Anyway there is an improvement in quality in the wake of including 5% of silica exhaust. The rate decline in compressive quality is 7.6 for 28 days when 20% fly ash debris is presented. 10% of fly ash debris has demonstrated the most extreme compressive quality. While 30% fly ash remains supplanted cement has created the least compressive quality. There is a 7.2% abatement in the quality when 5% silica is included.

Fig 4.1 compression test of a specimen

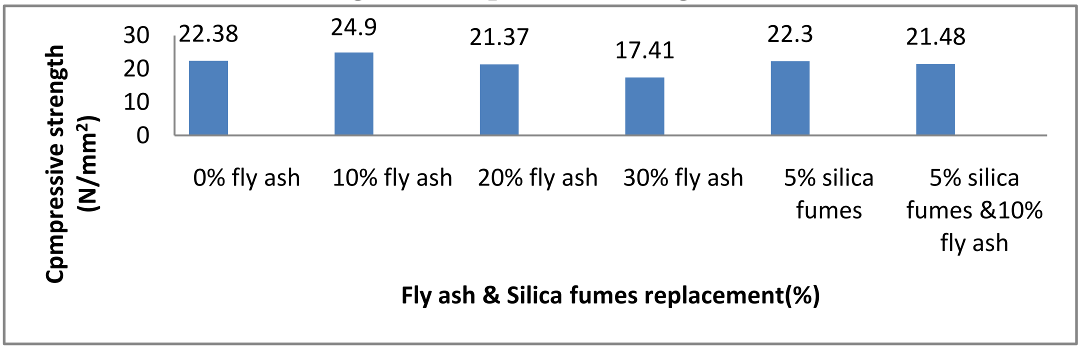
Table 4.1 The compressive strength of the specimen for 7 and 28days

Grade of concrete	Type	Compressive strength for 7 days (N/mm^2)	Compressive strength for 28 days (N/mm^2)
M 25	Cubes with 0% fly ash	22.38	26.85
	Cubes with 10% fly ash	24.9	29.08
	Cubes with 20% flyash	21.37	26.64
	Cubes with 30% fly ash	17.41	21.82

Table 4.2 The compressive strength of the specimen for 7 and 28days

Grade of concrete	Type	Compressive strength for 7 days (N/mm^2)	Compressive strength for 28 days (N/mm^2)
M 25	Cubes with 0% silica fumes	22.38	26.85
	Cubes with 5% silica fumes	22.30	26.76
	Cubes with 5% silica fumes & 10% fly ash	21.48	25.99

Fig.4.2 Compressive strength co



Compressive strength comparison for 7 days

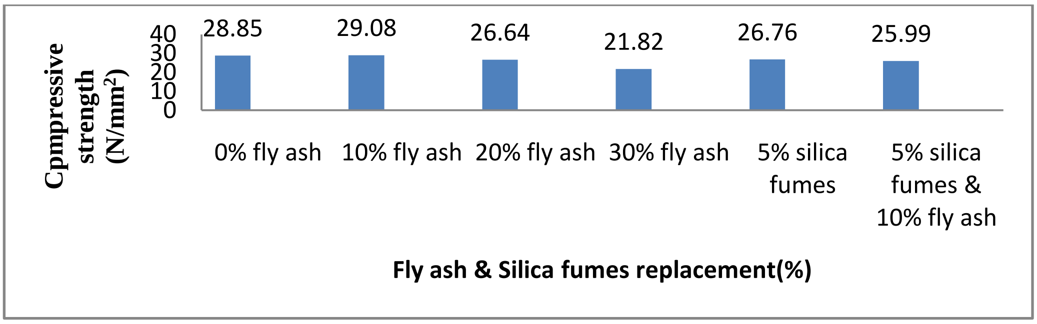


Fig.4.3 Compressive strength comparison for 28 days

4.2 SPLIT TENSILE STRENGTH

The Split Tensile quality of 150x300 mm chambers of M25 evaluation concrete with 0%, 10%, 20% and 30% of bond supplanted with fly ash debris is tried. The level of fly ash debris substitution on an expansion of 5% Silica for 7 and 28 days is appeared in Figure 4.5 and 4.6 individually. It is seen that the split rigidity of cement with fly ash remains is improved in the wake of including silica vapor. The rigidity is appeared in the table 4.3. Elasticity for 7 and 28days is appeared in the Fig 4.5 and 4.6 separately.

Fig.4.4 Split tensile test of specimen

Table 4.3 The tensile strength of the specimen for 7 and 28days

Grade of concrete	Type	Tensile strength for 7 days (N/mm^2)	Tensile strength for 28 days (N/mm^2)
M 25	Cylinders with 0% fly ash	2.9	3.77
	Cylinders with 10% fly ash	2.75	3.64
	Cylinders with 20% fly ash	2.45	3.00
	Cylinders with 30% fly	2.3	2.93

	ash		

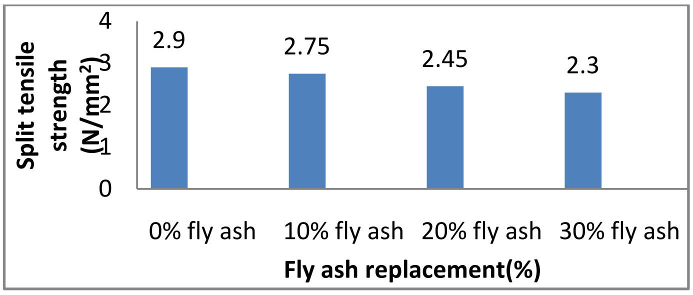


Fig.4.5 Split tensile strength comparison for 7 days

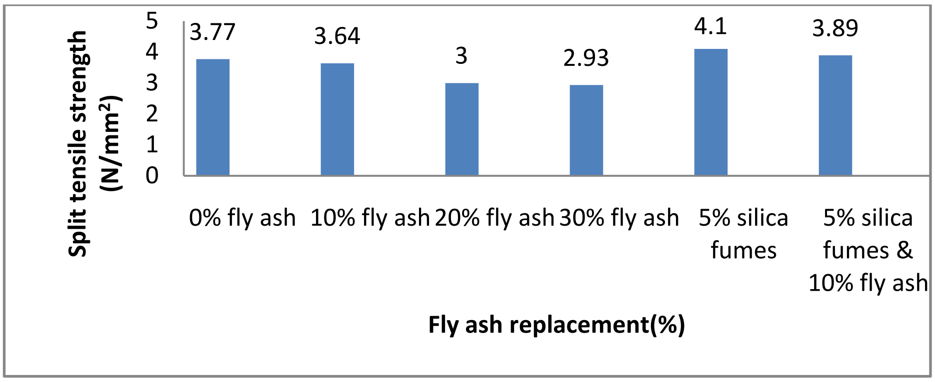


Fig.4.6 Split tensile strength comparison for 28 days

4.3 FLEXURAL STRENGTH

The Flexural strength of 500x100mm beams of M25grade concrete with 0%, 10%, 20% and 30% of cement replaced with fly ash and with a 10% percentage of fly ash replacement on an addition of 5% Silica fumes for 28 days are shown in table 4.4 and Figure 4.8.

Fig.4.7 Flexure test of specimen

Table 4.4 The flexural strength of the specimen for 28days

Grade of concrete	Type	Flexural strength for 28 days (N/mm^2)
M 25	Beams with 0% fly ash	11.83
	Beams with 10% fly ash	11.05
	Beams with 20% fly ash	10.49
	Beams with 30% fly ash	9.12

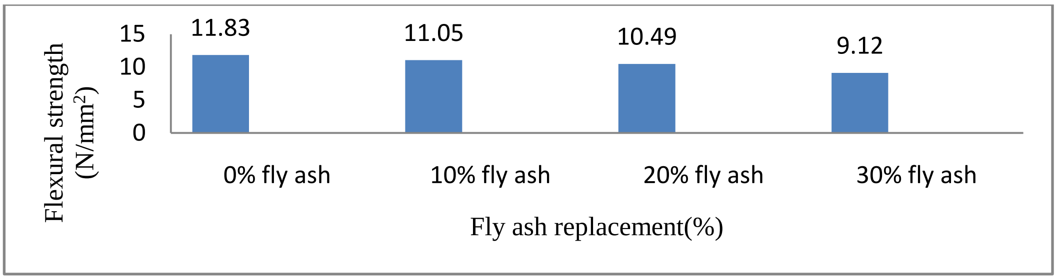


Fig.4.8 Flexural strength comparison for 28 days

CONCLUSION

Low volumes of fly ash remains improve the compressive quality of concrete and limited quantity silica vapor have demonstrated better outcomes. Fly ash debris supplanting with 10% delivered most elevated compressive quality. A limited quantity of silica exhaust impacts emphatically on elasticity and high volume of fly ash debris diminishes the rigidity. Flexural quality has demonstrated improvement with the diminishing of fly ash remains content. The compressive quality has diminished about 7.6% when 20% of fly ash debris has been supplanted with bond. There was a 24.36% diminishing when 30% fly powder has been supplanted. At the point when there is a 5% expansion of silica exhaust with a 10% fly ash debris substitution there was 9.9% decrement.

The expansion of silica vapor has indicated high increment in the rigidity.

References:

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